WHAT IS CLAIMED IS:

Sub A1

1. A method for plasma plating comprising:

positioning a substrate within a vacuum chamber;

positioning a depositant in a filament within the vacuum chamber;

reducing the pressure in the vacuum chamber to a level at or below 4 milliTorr;

introducing a gas into the vacuum chamber at a rate to raise the pressure in the vacuum chamber to a level at or between 0.1 milliTorr and 4 milliTorr;

applying a dc signal to the substrate at a voltage amplitude at or between 1 volt and 5000 volts;

applying a radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts; and

heating the depositant to a temperature at or above the melting point of the depositant to generate a plasma in the vacuum chamber.

Sub B1

2. The method of Claim 1, wherein reducing the pressure in the vacuum chamber to a level at or below 4 milliTorr includes reducing the pressure in the vacuum chamber to a level at or below 1.5 milliTorr, and wherein introducing the gas into the vacuum chamber at a rate to raise the pressure in the vacuum chamber to a level at or between 0.1 milliTorr and 4 milliTorr includes introducing the gas into the vacuum chamber at a rate to raise the pressure to a level at or between 0.5 milliTorr and 1.5 milliTorr.

3. The method of Claim 1, wherein applying the dc signal to the substrate at a voltage amplitude at or between 1 volt and 5000 volts includes applying a dc signal to the substrate at a voltage level at or between negative 500 volts and negative 750 volts.

4. The method of Claim 1, wherein applying the radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts includes applying the radio frequency signal to the substrate at a power level at or between 5 watts and 15 watts.

5. The method of Claim 1, wherein applying the radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts includes applying the radio frequency signal to the substrate at a power level around 10 watts.

6. The method of Claim 1, wherein applying the dc signal to the substrate includes applying the dc voltage at a negative polarity, and the plasma includes positive depositant ions.

~~7. The method of Claim 1, wherein reducing the pressure in the vacuum chamber to a level at or below 4 milliTorr includes reducing the pressure in the vacuum chamber to a level at or below 1.5 milliTorr, and introducing the gas into the vacuum chamber at a rate to raise the pressure in the vacuum chamber to a level at or between 0.1 milliTorr and 4 milliTorr includes introducing the gas into the vacuum chamber at a rate to raise the pressure to a level at or between 0.5 milliTorr and 1.5 milliTorr, wherein applying a dc signal to the substrate at a voltage amplitude at or between 1 volt and 5000 volts includes applying a dc signal to the substrate at a voltage level at or between negative 500 volts and negative 750 volts, and wherein applying the radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts includes applying the radio frequency signal to the substrate at a power level at or between 5 and 15 watts.~~

8. The method of Claim 1, wherein positioning the substrate within the vacuum chamber includes positioning the substrate on a platform.

9. The method of Claim 8, wherein the platform is a turntable operable to rotate the substrate.

10. The method of Claim 9, further comprising:

rotating the turntable at a revolutions per minute rate at or between 5 revolutions per minute and 30 revolutions per minute.

Sub B3

11. The method of Claim 9, further comprising: rotating the turntable at a rate of revolutions per minute at or between 12 revolutions per minute and 15 revolutions per minute.

12. The method of Claim 9, wherein the turntable includes an electrically conductive material that provides an electrically conductive path to the substrate, and applying the dc signal to the substrate and applying the radio frequency signal to the substrate include applying the dc signal and the radio frequency signal to the electrically conductive material of the turntable.

13. The method of Claim 12, wherein applying the dc signal to the substrate and applying the radio frequency signal to the substrate include applying the dc signal and the radio frequency signal to the electrically conductive material of the turntable using a commutator.

Sub B4

14. The method of Claim 12, wherein applying the dc signal to the substrate and applying the radio frequency signal to the substrate include applying the dc signal and the radio frequency signal to the electrically conductive material of the turntable using an electrically conductive brush.

15. The method of Claim 8, wherein the platform is included as part of the vacuum chamber.

16. The method of Claim 8, wherein the platform is a flat surface.

17. The method of Claim 8, wherein the platform includes a horizontal surface.

18. The method of Claim 8, wherein the platform includes a vertical surface.

19. The method of Claim 8, wherein the platform includes an inclined surface.

20. The method of Claim 8, wherein the platform includes a curved surface.

21. The method of Claim 8, wherein the platform includes a curvilinear surface.

22. The method of Claim 8, wherein the platform includes a helical surface.

23. The method of Claim 8, wherein the platform is a support structure.

24. The method of Claim 8, wherein the platform includes an electrically conductive material.

25. The method of Claim 8, wherein the platform is a conductive plate.

26. The method of Claim 8, wherein the platform includes a roller.

Sub C15

27. The method of Claim 1, further comprising:
mixing the dc signal and the radio frequency signal to generate a mixed signal, and wherein applying the dc signal to the substrate and applying the radio frequency signal to the substrate includes applying the mixed signal to the substrate.

28. The method of Claim 27, wherein the mixing the dc signal and the radio frequency signal includes mixing a negative dc signal and the radio frequency signal.

29. The method of Claim 27, further comprising:
balancing the mixed signal by minimizing the standing wave reflected power.

30. The method of Claim 29, wherein minimizing the standing wave reflected power is achieved using a manual control.

31. The method of Claim 29, wherein minimizing the standing wave reflected power is achieved using an automatic control.

Sub A2

32. The method of Claim 1, further comprising:
positioning the filament at a desired location relative to the substrate.

33. The method of Claim 32, wherein positioning the filament includes positioning the filament a distance from the substrate.

34. The method of Claim 33, wherein the distance is at or between 0.1 inches and 6 inches when the depositant

in the filament is to be deposited as a base layer.

35. The method of Claim 34, wherein the distance is at or between 2.75 inches and 3.25 inches when the depositant in the filament is to be deposited as the base layer.

36. The method of Claim 33, wherein the distance is at or between 0.1 inches and 6 inches when the depositant in the filament is to be deposited as a transition layer.

37. The method of Claim 36, wherein the distance is at or between 2.75 inches and 3.25 inches when the depositant in the filament is to be deposited as the transition layer.

38. The method of Claim 33, wherein the distance is at or between 0.1 inches and 6 inches when the depositant in the filament is to be deposited as a working layer.

39. The method of Claim 38, wherein the distance is at or between 2.0 inches and 2.5 inches when the depositant in the filament is to be deposited as the working layer.

40. The method of Claim 1, further comprising:

positioning the filament at a desired location relative to the substrate;

positioning a second depositant of the same type as the depositant in a second filament within the vacuum chamber; and

positioning the second filament at a desired location relative to the substrate.

41. The method of 40, further comprising positioning the filament a distance from the second filament.

42. The method of Claim 41, wherein the distance is at or between 0.1 inches and 6 inches when the depositant in the filament is to be deposited as a base layer.

Sub C17 cncld

43. The method of Claim 42, wherein the distance is at or between 3.0 inches and 4.0 inches when the depositant in the filament is to be deposited as the base layer.

44. The method of Claim 41, wherein the distance is at or between 0.1 inches and 6 inches when the depositant in the filament is to be deposited as a transition layer.

45. The method of Claim 44, wherein the distance is at or between 3.0 inches and 4.0 inches when the depositant in the filament is to be deposited as the transition layer.

46. The method of Claim 41, wherein the distance is at or between 0.1 inches and 6 inches when the depositant in the filament is to be deposited as a working layer.

47. The method of Claim 46, wherein the distance is at or between 2.5 inches and 3.0 inches when the depositant in the filament is to be deposited as the working layer.

Sub A2 cont'd

48. The method of Claim 1, further comprising: an array of substrates and the substrate is provided as one of the array of substrates;

positioning the filament at a desired position relative to outwardly facing surfaces of the array of substrates;

positioning a second depositant in a second filament within the vacuum chamber; and

positioning the second filament at a desired position relative to inwardly facing surfaces of the array of substrates.

Sub A2

49. The method of 48, wherein the weight of the second depositant is 20 to 80 percent less than the weight of the depositant.

50. The method of 49, wherein the weight of the second depositant is 40 to 50 percent less than the weight of the depositant.

Sub A3

51. The method of Claim 1, further comprising: positioning the substrate at a desired location relative to the filament.

52. The method of Claim 1, further comprising: positioning a second depositant in a second filament within the vacuum chamber before reducing the pressure in the vacuum chamber to a level at or below 4 milliTorr; and

heating the second depositant to a temperature at or above the melting point of the second depositant to generate a second plasma in the vacuum chamber after the prior plasma has been generated.

53. The method of Claim 52, wherein the depositant forms a base layer on the substrate and the second depositant forms a working layer on the base layer.

54. The method of Claim 51, further comprising:

Sub Att D'

positioning a third depositant in a third filament within the vacuum chamber before reducing the pressure in the vacuum chamber to a level at or below 4 milliTorr; and

heating the third depositant to a temperature at or above the melting point of the third depositant to generate a third plasma in the vacuum chamber after the second plasma has been generated.

55. The method of Claim 54, wherein the depositant forms a base layer on the substrate, the second depositant forms a transition layer on the base layer, and the third depositant forms a working layer on the transition layer.

Sub B

56. The method of Claim 1, wherein the radio frequency signal is provided at a frequency in the kilohertz range.

57. The method of Claim 1, wherein the radio frequency signal is provided at a frequency in the megahertz range.

58. The method of Claim 1, wherein the radio frequency signal is provided at a frequency of 13.56 kilohertz.

59. The method of Claim 1, wherein the radio frequency signal is provided at a frequency reserved for industrial applications.

60. The method of Claim 1, further comprising: cleaning the substrate to remove foreign materials and oils.

61. The method of Claim 1, further comprising: cleaning the substrate to achieve white metal clean.

62. The method of Claim 1, further comprising: cleaning the substrate before positioning the substrate within the vacuum chamber.

63. The method of Claim 62, wherein the cleaning the substrate includes cleaning the substrate to meet a defined standard.

64. The method of Claim 63, wherein the standard is defined by Steel Structures Painting Council (SSPC).

65. The method of Claim 63, wherein the standard is SSPC-5.

66. The method of Claim 63, wherein the standard is SSPC-10.

67. The method of Claim 62, wherein the cleaning the substrate includes abrasively blasting the substrate.

68. The method of Claim 1, wherein the gas is introduced through a control valve.

69. The method of Claim 1, wherein the depositant is a metal.

70. The method of Claim 1, wherein the depositant is a metal alloy.

71. The method of Claim 1, wherein the depositant is gold.

72. The method of Claim 1, wherein the depositant is titanium.

73. The method of Claim 1, wherein the depositant is chromium.

74. The method of Claim 1, wherein the depositant is nickel.

75. The method of Claim 1, wherein the depositant is silver.

76. The method of Claim 1, wherein the depositant is tin.

77. The method of Claim 1, wherein the depositant is indium.

78. The method of Claim 1, wherein the depositant is lead.

79. The method of Claim 1, wherein the depositant is copper.

80. The method of Claim 1, wherein the depositant is palladium.

81. The method of Claim 1, wherein the depositant is a silver/palladium metal alloy.

82. The method of Claim 1, wherein the depositant is carbon.

~~83. The method of Claim 1, wherein the depositant is a nonmetal~~

84. The method of Claim 1, wherein the depositant is a ceramic.

85. The method of Claim 1, wherein the depositant is a metal carbide.

86. The method of Claim 1, wherein the depositant is a metal nitride.

87. The method of Claim 1, wherein the depositant is provided in a form from the class consisting of a pellet, a wire, a granule, a powder, a ribbon, and a strip.

88. The method of Claim 1, wherein the gas is an inert gas.

89. The method of Claim 1, wherein the gas is a

noble gas.

90. The method of Claim 1, wherein the gas is argon.

91. The method of Claim 1, wherein the gas is xenon.

92. The method of Claim 1, wherein the gas is radon.

93. The method of Claim 1, wherein the gas is helium.

94. The method of Claim 1, wherein the gas is neon.

95. The method of Claim 1, wherein the gas is krypton.

96. The method of Claim 1, wherein the gas is oxygen.

97. The method of Claim 1, wherein the gas is nitrogen.

98. The method of Claim 1, wherein the gas is noncombustible.

99. The method of Claim 1, wherein the plasma includes gas ions and depositant ions.

100. The method of Claim 99, wherein the gas ions and the depositant ions of the plasma include positively

charged ions.

101. The method of Claim 99, wherein the gas ions and the depositant ions of the plasma include negatively charged ions.

102. The method of Claim 1, wherein the gas is argon and the despositant is a metal allow of silver/palladium, and the plasma includes argon ions and silver/palladium ions.

103. The method of Claim 1, wherein the filament is a tungsten basket.

104. The method of Claim 1, wherein the filament is a boat.

105. The method of Claim 1, wherein the filament is a coil.

106. The method of Claim 1, wherein the filament is a crucible.

107. The method of Claim 1, wherein the filament is a ray gun.

108. The method of Claim 1, wherein the filament is an electron beam gun.

109. The method of Claim 1, wherein the filament is a heat gun.

110. The method of Claim 1, wherein the filament is

a support structure.

Sub A7 cont'd

111. The method of Claim 1, wherein heating the depositant includes supplying a current through the filament.

Sub A7

112. The method of Claim 111, wherein heating the depositant includes incremental staging of the current to the filament to achieve a more even heat distribution in the depositant.

113. The method of Claim 111, wherein the current is an alternating current.

Sub B12

114. The method of Claim 113, wherein the amplitude of the alternating current is controllably increased such that the depositant is more uniformly heated and melted.

115. The method of Claim 1, wherein heating the depositant includes heating the depositant through heat generated by a chemical reaction between the depositant and an agent.

116. The method of Claim 1, wherein heating the depositant includes heating the depositant through the use of microwave energy.

117. The method of Claim 1, wherein the method does not include the addition of a magnet to produce a magnetic field near the substrate that affects the attraction of the ions of the plasma to the substrate.

Sub C21

118. The method of Claim 1, wherein the plasma forms a layer on the substrate with a thickness at or between 500 and 20,000 Angstroms.

~~119. The method of Claim 1, wherein the plasma forms a layer on the substrate with a thickness at or between 3,000 and 10,000 Angstroms.~~

~~120. The method of Claim 1, wherein the plasma forms a layer on the substrate that can be controlled to a thickness of 500 Angstroms.~~

Sub C2 cont'd

~~121. The method of Claim 1, further comprising: backsputtering the substrate before heating the depositant to a temperature at or above the melting point of the depositant to generate a plasma in the vacuum chamber.~~

~~122. The method of Claim 1, further comprising: performing backsputtering before heating the depositant that includes:~~

~~reducing the pressure in the vacuum chamber to a level at or below 100 milliTorr;~~

~~introducing a gas into the vacuum chamber at a rate to raise the pressure in the vacuum chamber at or between 20 milliTorr and 100 milliTorr;~~

~~applying a dc signal to the substrate at a voltage amplitude at or between 1 volt and 4000 volts; and~~

~~applying a radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts.~~

Sub B3

123. The method of Claim 122, wherein reducing the pressure in the vacuum chamber to a level at or below 100 milliTorr includes reducing the pressure in the vacuum chamber to a level at or below 50 milliTorr, and wherein introducing the gas into the vacuum chamber at a rate to raise the pressure in the vacuum chamber at or between 20 milliTorr and 100 milliTorr includes introducing the gas into the vacuum chamber at a rate to raise the pressure at or between 20 milliTorr and 50 milliTorr.

124. The method of Claim 122, wherein applying the dc signal to the substrate at a voltage amplitude at or between 1 volt and 4000 volts includes applying a dc signal to the substrate at a voltage amplitude at or between 100 volts and 250 volts.

125. The method of Claim 122, wherein applying the radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts includes applying the radio frequency signal to the substrate at a power level at or between 5 and 15 watts.

126. The method of Claim 122, wherein applying the dc signal to the substrate includes applying the dc voltage at a negative polarity.

127. The method of Claim 122, wherein backsputtering is performed for a period of time at or between 30 seconds and one minute.

128. The method of Claim 122, wherein backsputtering is performed until the rate of visible microarcing is significantly reduced.

Sub A8

129. A method for plasma plating comprising:

positioning a substrate within a vacuum chamber;

positioning a depositant in a filament within the vacuum chamber;

reducing the pressure in the vacuum chamber to a level at or between 0.1 milliTorr and 4 milliTorr;

applying a dc signal to the substrate at a voltage amplitude at or between 1 volt and 5000 volts;

applying a radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts; and

heating the depositant to a temperature at or above the melting point of the depositant to generate a plasma in the vacuum chamber.

130. The method of Claim 129, wherein applying the dc signal to the substrate at a voltage amplitude at or between 1 volt and 5000 volts includes applying a dc signal to the substrate at a voltage amplitude at or between 500 volts and 750 volts.

131. The method of Claim 129, wherein applying the dc signal to the substrate includes applying the dc voltage at a negative polarity, and the plasma includes positive depositant ions.

132. The method of Claim 129, wherein applying the radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts includes applying the radio frequency signal to the substrate at a power level at or between 5 and 15 watts.

133. The method of Claim 129, wherein applying a dc signal to the substrate at a voltage amplitude at or between 1 volt and 5000 volts includes applying a dc signal to the substrate at a voltage amplitude at or between 500 volts and 750 volts with a negative polarity, and wherein applying the radio frequency signal to the substrate at a power level at or between 1 watt and 50 watts includes applying the radio frequency signal to the substrate at a power level at or between 5 and 15 watts.

134. A system for plasma plating comprising:

a vacuum chamber at a pressure defined by a range that extends from 0.1 milliTorr to 4 milliTorr;

a filament positioned within the vacuum chamber and operable to receive a depositant;

a depositant positioned at the filament;

a platform positioned within the vacuum chamber;

a substrate positioned at the platform;

a dc power supply generating a dc signal at a voltage amplitude defined by a range that extends from 1 volt to 5000 volts;

a radio frequency transmitter generating a radio frequency signal at a power level defined by a range that extends from 1 watt to 50 watts;

an electrically conductive path that electrically couples the dc signal and the radio frequency signal to the substrate; and

a filament power control electrically coupled to the filament and generating a current through the filament at an amplitude to generate heat in the filament to melt the depositant.

135. The system of Claim 134, further comprising a gas in the vacuum chamber.

136. The system of Claim 135, wherein the gas is a noble gas.

137. The system of Claim 135, wherein the gas is an inert gas.

138. The system of Claim 135, wherein the gas is argon.

139. The system of Claim 134, further comprising:

a vacuum system operable to assist with maintaining the pressure in the vacuum chamber at the pressure defined by the range that extends from 0.1 milliTorr to 4 milliTorr; and

a gas flowing into the vacuum chamber operable to assist with maintaining the pressure in the vacuum chamber at the pressure defined by the range that extends from 0.1 milliTorr to 4 milliTorr.

140. The system of Claim 134, wherein the filament and the depositant are positioned at a distance no greater than 6 inches from the substrate.

141. The system of Claim 134, wherein the vacuum chamber is at a pressure defined by a range that extends from 0.5 milliTorr and 1.5 milliTorr.

142. The system of Claim 134, wherein the dc power supply is generating a dc signal at a voltage amplitude defined by a range that extends from 500 volts to 750 volts.

143. The system of Claim 134, wherein the dc signal is provided at a negative polarity.

144. The system of Claim 134, wherein the radio frequency transmitter is generating a radio frequency signal at a power level defined by a range that extends from 5 watt to 15 watts.

145. The system of Claim 134, wherein the vacuum chamber is at a pressure defined by a range that extends from 0.5 milliTorr and 1.5 milliTorr, the dc power supply is generating a dc signal at a voltage amplitude defined by a range that extends from negative 500 volts to negative 750 volts, and the radio frequency transmitter is generating a radio frequency signal at a power level defined by a range that extends from 5 watt to 15 watts.

146. The system of Claim 134, further comprising:

a dc signal/radio frequency signal mixer mixing the dc signal and the radio frequency signal before the electrically conductive path electrically couples the dc signal and the radio frequency signal to the substrate.

147. The system of Claim 146, further comprising:

a radio frequency balancing network receiving the dc signal and the radio frequency signal generated by the dc signal/radio frequency signal mixer and minimizing the standing wave reflected power.

148. The system of Claim 147, wherein the minimizing the standing wave reflected power is performed using an automatic control.

149. The system of Claim 147, wherein the minimizing the standing wave reflected power is performed using a manual control.

150. The system of Claim 134, wherein a magnet is not introduced to produce a magnetic field near the substrate.